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A Comparison of the Changes Observed in Relation to Various Forms of Conditioning or Wrestlers and Non-Wrestlers at Various Intervals

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A COMPARISON OF THE CHANGES OBSERVED IN RELATION TO VARIOUS FORMS OF CONDITIONING ON WRESTLERS AND NON-WRESTLERS AT VARIOUS INTERVALS

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This thesis, submitted by Percy R. Morrison in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

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ABSTRACT

The purpose of this study was to analyze the changes observed during a pre-season conditioning program with respect to predetermined physiological areas among intercollegiate wrestlers as measured before, during, at the end of the season and six weeks after the conclusion of the season.

Inter-group and intra-group comparisons of results were made between the experimental group of twenty collegiate wrestlers, and the control group, consisting of ten male subjects enrolled in required physical education classes.

Leg, back and arm strength data of the subjects were recorded using a Leg-Back dynamometer and a cable tensiometer. Cardiovascular fitness was measured by the Harvard Step Test.

It was found that arm and leg strength of the collegiate wrestlers did increase significantly during the experimental period. Non-significant changes recorded by the experimental group were an increase in back strength and a decrease in cardiovascular fitness as shown by the Harvard Step Test results.

The control group did not record a significant difference in any of the areas tested.

The pre-season conditioning program carried on for eight weeks did produce significant changes in the scores of the experimental group. In comparing the mean scores of the pre-season test with those of the retest six weeks after the conclusion of the season, the experimental group increased in leg strength by 225.75 pounds. Arm strength gains amounted to 27.25 pounds and back strength showed the smallest gain of

4.50 pounds. However, the cardiovascular fitness of the subjects in the experimental group tended to deteriorate very quickly after the conclusion of the season giving indication of a need for a program of deconditioning.

CHAPTER I

INTRODUCTION

Down through the years, many coaches have been faced with the perplexing problem of preparing an athletic team for intense competition and the rigorous grind of the practice season. The coaches of the wrestling teams at the University of North Dakota are intensely interested in finding a way in which the physical condition of the college wrestler can be measured. After having secured these measurements, the staff is inquisitive as to whether or not a level of conditioning is reached whereby the wrestlers can go ahead and engage in this sport without any adverse effects.

Statement of the Problem

This study was undertaken to analyze the changes observed during a pre-season conditioning program with respect to predetermined physiological items on intercollegiate wrestlers before, during, at the end of the season and six weeks after the close of the season.

The writer tested leg strength, back strength, and arm strength of the subjects, using a Leg-Back dynamometer and a cable tensiometer. Cardiovascular fitness was measured by the Harvard Step Test. By analyzing the results of these tests, the writer studied the pre-season conditioning program used in the preparation for the 1965-1966 competitive season.

Need for Study

The intense competition in the present day world of inter-collegiate athletics calls for the athlete to be in top physical condition in order to meet the challenge confronting him.

Because of the demands of a competitive season confronting a coach, the writer has become interested in the conditioning aspect of wrestler preparation and the results of this type of a program.

The collegiate wrestler of today must possess superior strength, endurance and fitness in order to be able to compete for the time required of him during each dual match for an entire season.

As a coach, the writer, wished to gain insight into a method which might enable the athlete to develop and maintain a state of physical condition which could enable him to put forth a maximum effort when necessary.

Limitations

This study was limited to the members of the 1965-1966 Varsity and Freshmen Wrestling teams of the University of North Dakota and two sections of male students enrolled in physical education service classes at the University of North Dakota.

Definition of Terms

The experimental group refers to the thirty-five members of the 1965-1966 Varsity and Freshmen Wrestling teams at the University of North Dakota.

The control group refers to the eighteen members randomly selected from two sections of the physical education service program of the University of North Dakota.

Leg-Back dynamometer refers to the apparatus employed in measuring leg strength and back strength of the subjects tested.

Cable tensiometer refers to the apparatus used in measuring arm strength of elbow flexion of the subjects in the testing program.

Harvard Step Test refers to the test administered to the subjects in the testing program to determine cardiovascular fitness. Each subject was instructed to step up on to and off from a bench 20 inches in height for a period of five minutes. Each subject must take at least thirty steps a minute for the duration of the test. After five minutes, the subject was seated for a minute and pulse rates were recorded from one to one and a half minutes, two to two and a half minutes, and three to three and a half minutes.

Review of Related Literature

The amount of literature directly related to the sport of wrestling relative to the topic selected by the writer is somewhat limited. However, research which has been conducted in the areas of developmental and conditioning programs is numerous. An attempt was made to gather as much pertinent information as possible referring to the topic of this study.

E. Chui[1] conducted a study to determine the effects of a systematic weight training program on athletic power of college students. One group participated in a program of weight training two or three times a week and another group had no weight training but participated in regular physical education classes. The conclusions

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[1]Edward Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, XXI (October, 1950), 188-194.

drawn from this study showed that the weight training group gained more consistently in the Sargent Jump Test, running Sargent Jump, standing broad jump, eight pound shot put, twelve pound shot put, and sixty yard dash, than did the control group.

A study conducted by E. Capen[2] was undertaken to determine the effects of systematic weight training on strength, athletic power, and muscular endurance. Two groups of college men were used in the study over an eleven week period. One group participated in a weight training class while the other group was involved in a conditioning class in physical education. Based on the findings of the study, Capen concluded that the weight training group improved more than did the conditioning group. Capen found that weight training did not result in muscular tightness nor did weight training decrease the speed of muscular contraction. This study showed weight training to be as effective for developing muscular endurance as the conditioning program.

R. A. Dire's[3] study involved 100 students participating in physical education classes. Half of the students participated in a weight training program for twelve weeks while the other half engaged in regular activities of the physical education program for the same period. The study attempted to determine if a program of resistive weight training increased muscular strength, endurance, power, speed, and agility and if participation in this type of a program increased

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[2]Edward K. Capen, "The Effect of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, XXI (May, 1950), 83-93.

[3]Robert A. Dire, "An Analysis of the Effects of a Weight Training Program on Selected Measures of Muscular Strength, Endurance, Power, Speed and Agility on Adolescent Boys," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1959).

skills more than did participation in a regular physical education activity class. The study revealed that a systematic weight training program did produce significant changes in the selected measures of muscular strength, endurance, power, speed and agility.

A study conducted by R. J. Brown and D. R. Riley[4] at Springfield College observed the effects of a weight training program on leg strength and vertical jump. A five week period of weight training by the experimental group showed the results to be significant at the .01 level of confidence in leg strength and vertical jump.

B. M. Wilkin[5] conducted a study to determine the effect of weight training on the speed of movement and found that weight training did not hinder the speed of high school students at Oakland Technical High School in California. His results also suggested that daily training with weights can improve muscular endurance.

W. S. Zorbas and P. V. Karpovich[6] directed a study to show that training with weights did not slow down the athlete or hamper his speed of muscular contractions. Six hundred college age men participated in the study, with 300 constituting a control group and 300 making up an experimental group. The conclusion of their study indicated that the weight lifters were superior in the speed of arm rotation as compared to the non-weight lifting group.

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[4]Robert J. Brown and Douglas R. Riley, "The Effect of Weight Training on Leg Strength and the Vertical Jump," (unpublished thesis, Springfield College, June, 1957).

[5]Bruce M. Wilkin, "The Effect of Weight Training on Speed of Movement," Research Quarterly, XXIII (October, 1952), 361.

[6]William S. Zorbas and Peter V. Karpovich, "The Effect of Weight Lifting Upon the Speed of Muscular Contractions," Research Quarterly, XXII (May, 1951), 145-148.

In a study conducted with hockey players, R. H. Peters[7] investigated the effects of a pre-season conditioning program related to strength, endurance, fatigue and maximum load level. The findings of his study enabled Peters to conclude that back strength increased until the end of the season then dropped off. Endurance improved until the start of the season, leveled off, then dropped six weeks after the season was underway.

R. L. Campbell[8] undertook a study to determine the effects of weight training when used as a supplement to normal physical training programs. His subjects included one hundred thirty male students participating in regular physical education classes and on various athletic teams. The findings confirmed that the gains made by the weight training group were greater during the first half of the season as compared to the gains made during the last half of the season, showing weight training should be continuous throughout the season.

J. A. Mittun[9] investigated the effects of a weight training program on selected measures of power, agility and basketball skills of adolescent boys and found that an eight week period of weight training did significantly affect the power and skill measures of the weight training group as compared to a non-weight training group.

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[7]Robert H. Peters, "An Investigation of Certain Effects of a Pre-Season Conditioning Program of Selected Intercollegiate Ice Hockey Players at Various Times Before, During, and After the Playing Season," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1964).

[8]Robert L. Campbell, "The Effects of Participation in Selected Programs of Weight Training on the Physical Fitness of Athletes," (doctoral dissertation, State University of Iowa, August, 1960).

[9]James A. Mittun, "An Analysis of the Effects of a Weight Training Program on Selected Measures of Power, Agility, and Basketball Skills in Adolescent Boys," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1960).

A similar study was conducted by R. F. Huffman[10] using adolescent boys to determine the effects of a weight training program on selected factors of athletic skill as compared to the performance of a non-weight training group. The study involved fifty-one ninth grade boys subdivided into a weight training group of thirty-four and a non-weight training group of seventeen. The study was carried out for six weeks and employed the "t" technique for testing. The study revealed that weight training did improve the athletic skill of the subjects.

M. C. Lempe[11], using his high school wrestling squad, conducted a study with part of the team participating in a weight training program, in addition to the regular wrestling program, and the rest of the team remaining in the regular wrestling program. The study was set up to determine if a weight training program affected muscular strength, endurance, explosive power, speed and agility. After eight weeks of weight training, the study showed that significant changes did occur in the selected measures of both groups.

CARDIOVASCULAR FITNESS

Michael and Cureton[12] investigated the effects of physical training on the cardiovascular systems of three graduate students at

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[10]Roger F. Huffman, "An Analysis of the Effects of a Weight Training Program on Selected Factors of Athletic Skill in Adolescent Boys," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1959).

[11]Myron C. Lempe, "An Analysis of the Effects of a Progressive Weight Training Program on Selected Measures of Muscular Strength, Endurance, Explosive Power, Speed and Agility of a Varsity High School Wrestling Squad," (unpublished Masters Thesis, Department of Physical Education, University of North Dakota, 1963).

[12]Ernest D. Michael and T. K. Cureton, "Effects of Physical Training on Cardiac Output at Ground Level and at 15,000 Feet Simulated Altitude," Research Quarterly, XXIV (December, 1953), 446-452.

ground level and at fifteen thousand feet of simulated altitude. The subjects worked out five days a week with the training being intensified each week for twelve weeks. Through their findings, the conclusion of their study showed the pulse rate decreased during training with the mean pulse rate reaching the low after eight weeks of training. The strengthening of the cardiovascular system can be attributed to the training the students were subjected to in the study.

Gemmil, Booth and Pocock[13] conducted a study similar to the one conducted by Michael and Cureton except the training for the subjects consisted of riding a stationary bicycle at a definite speed and load to study metabolic, respiratory and circulatory responses to the work load.

They stated:

> The study concluded in its findings that training to light muscular work brings about an increase in the efficiency of the cardiac and respiratory mechanisms rather than a change in the efficiency of the muscle. This efficiency will allow one to do the same amount of work with fewer subjective symptons of distress and fatigue.

Gemmil, Booth and Pocock also found as the experiment progressed, the pulse rate decreased and the recovery time for the pulse rate to return to normal also declined.

P. M. Dawson[14] conducted a self study over a period of time extending from April 1, 1914, to June 17, 1916. He participated in

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[13]C. Gemmil, W. Booth and B. Pocock, "The Physiological Effect of Daily Repetition of the Same Amount of Light Muscular Work," American Journal of Physiology, XCII (February, 1930), 253.

[14]Percy M. Dawson, "Effect of Physical Training and Practice on The Pulse Rate and Blood Pressures During Activity and During Rest, With a Note on Certain Acute Infections and In the Distress Resulting From Exercise," The American Journal of Physiology, I (October, 1919), 443-473.

a conditioning program to determine the effect on the diastolic and systolic pressures and pulse rate of himself. The conclusions drawn by the author on the effect of training on pulse rate showed it had a slowing effect. When a trained individual engaged in physical activity, he accomplished more work with less apparent exertion and less subjective stress.

Tuttle and Walker[15] used fourteen track athletes and collected data at the beginning of the season, mid-season and end of the season on the resting pulse rate, pulse rate after exercise, rate above the resting pulse rate after exercise, primary recovery time, recovery time and recovery pulse. The study showed changes in pulse rate recovery favored efficiency of the heart since fewer beats were required to establish the resting level. They also stated:

> Whenever altered cardiac responses occurred, it was always in favor of more efficient heart action.

Henderson, Haggard, and Dolley[16] undertook a study to determine the circulation during rest and exercise of fifty college men between 18 and 25 years of age. One-third of the group were athletes, one-third were individuals involved in some form of mild exercise for pleasure and the remainder of the group was made up of subjects not involved in any physical activity. The subjects rode a bicycle ergometer at a fixed rate of work per minute. The authors stated:

> In athletes the pulse rate tends to be much slower and the stroke volume distinctly larger both during rest and

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[15]W. W. Tuttle and Frank H. Walker, "The Effect of a Season of Training and Competition on the Response of the Hearts of High School Boys," Research Quarterly, XI (December, 1940), 78-81

[16]Yandell Henderson, Howard W. Haggard, and Frank S. Dolley, "The Efficiency of The Heart and The Significance of Rapid and Slow Pulse Rates," The American Journal of Physiology, LXXXII (November, 1927), 512-524.

> exercise than in non-athletes. The slowness of pulse is found to have the advantage of allowing longer diastoles with ample time for the ventricles to relax and fill. As a consequence, also the stroke volume in athletes during exertion may be increased considerably, 50 per cent or more, over that during rest, with a corresponding gain in the minute volume of the circulation and its oxygen transporting capacity. The athlete's heart is supernormal

Rothacher[17] took forty athletes and forty non-athletes and tested them on the Schneider Efficiency Test. He reported that the heart rate in an athlete is lower than in a non-athlete in a prone position at rest; and on standing, the heart rate of the athlete rises less than in a non-athlete. He also found the heart rate after exercise (20 knee raises in 5 seconds) is lower in the athlete than the non-athlete. He concluded by stating:

> This leads one to conclude that in the athlete any exertion on the part of the subjects has less effect on the heart rate than does the same exertion on the part of the non-athlete.

E. Capen[18] concluded in the study conducted on college men participating in a systematic weight training program that this type of program is as effective for developing circulo-respiratory endurance as was the program followed by the control group.

Peters'[19] study used the Harvard Step Test to measure circulo-respiratory endurance, and the results of his conditioning program

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[17]J. L. Rothacher, "A Study of Athletic Condition in Relation to Circulation and Weight," Research Quarterly, VI (May, 1935), 62-69.

[18]Edward K. Capen, "The Effect of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, XXI (May, 1950), 83-93.

[19]Robert H. Peters, "An Investigation of Certain Effects of a Pre-Season Conditioning Program of Selected Intercollegiate Ice Hockey Players at Various Times Before, During, and After the Playing Season," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1964).

showed the Harvard Step Test performance improved until the season began, then declined, yet the last reading was better than the reading taken at the pre-season test. These findings showed improvement in cardiovascular fitness occurred in the athletes in this study.

In summary of the literature reviewed, it was found that most of the studies conducted conclusively show favorable results from weight training programs as to their effects on the subjects. Improvement in over-all physical fitness resulted as well as in fitness of the cardiovascular system.

CHAPTER II

METHODOLOGY

The program of pre-season conditioning was drawn up by the writer under the supervision of Mr. Harold L. Pedersen, Varsity Wrestling Coach of the University of North Dakota and Mr. W. C. Koenig. The tests used in this study were selected on the basis of the type of conditioning program conducted.

The pre-season conditioning program conducted for the 1965-1966 season began October 4, 1965, with a general call to all wrestling candidates on campus. The first day was spent issuing work out equipment and testing. Each subject was tested for leg strength, back strength, arm strength (elbow flexion of 90° angle) and for cardiovascular fitness using the Harvard Step Test.

Leg strength was measured by a Leg-Back dynamometer. The subject placed a six inch web belt around his waist and both ends were fastened to a bar which was held in both hands with an alternate grip. The subject was instructed to keep the back straight, feet fixed on the platform, and flex the knees to a forty or forty-five degree angle. From a hook on the bar, the dynamometer was suspended and fastened to a hook on a platform by means of an adjustable chain. The subject placed one foot on each side of the hook on the platform and after the apparatus had been adjusted to each individual's height,

he was instructed to attempt to straighten his legs, with the amount of strength being registered by the dynamometer.

Back strength was measured by the use of the same dynamometer, except the web belt was removed from around the subject's waist and the bar. The subject being tested took his position on the platform with his feet placed on alternate sides of the hook. The bar was grasped with an alternate grip and the dynamometer hooked up. The knees were locked in a position so the legs were straight throughout the test. Flexion on the lumbo-sacral joint was set at the start of the test at fifteen degrees and the strength of the subject's back was measured on the dynamometer as he attempted to straignten the back.

Arm strength was measured by the use of a cable tensiometer. Each subject was placed at one end of a table sitting on a small bench, with his chest placed against the end of the table, legs extended and his free arm placed behind his back in a ninety-degree angle position. The arm to be measured was placed on the table and the forearm was flexed to a ninety-degree angle with a web cuff placed below the subject's wrist. A cable was attached to the cuff and anchored to the opposite end of the table. The tensiometer was attached to the cable and the strength of the subject's elbow flexion was measured by attempting to draw the fist to the shoulder.

As a measure of cardiovascular fitness, the Harvard Step Test was used. Each subject would step up on to and off from a bench twenty inches in height at a constant rate of at least thirty steps per minute for five minutes. After completion of five minutes of stepping on and off the bench, the subject sat on the bench at rest for one minute and his pulse rate was then recorded for thirty seconds.

Another thirty second period of time elapsed and the pulse rate was recorded for the time between two and two and a half minutes. Another pulse rate recording was taken between three and three and a half minutes to conclude the step test.

The testing schedule for the first recording was extended over a two day period of time because of the time element involved in testing each subject. The total time spent on testing each individual amounted to fifteen minutes. Retests were conducted on the athletes after one month of pre-season conditioning, one month after the season began, at the conclusion of the season, and six weeks after the conclusion of the season. The control group was tested at the same time of the pre-season test and six weeks after the conclusion of the season.

The first week of the pre-season conditioning program was cut to a three-day work out because of the stiffness and soreness experienced by the athletes in the initial phases of the program.

After October 11, 1965, the wrestling squad worked out five days a week for the duration of the pre-season conditioning program extending to November 19, 1965.

Each workout began with the athletes running cross country over a designated course or "fartlek". The distance run varied from workout to workout, with the distance from two miles to four miles depending on the previous day's workout. After covering the designated course, the athletes reported to the wrestling room for conditioning and stretching exercises. A list of the routine followed for loosening up appears in the Appendix A.

After going through the loosening up drills and exercises, the athletes reported to the weight lifting room or apparatus gymnasium.

A weight training program and a gymnastic routine was drawn up with the approval of Mr. H. L. Pedersen. These programs were alternated; weights were worked on three days and gymnastic apparatus two days of one week. The following week three days were used for gymnastic apparatus work and two days were spent on weight training. This alternate course was followed for the duration of the conditioning program. A copy of the weight training program and gymnastic routine appears in the Appendix A.

The athletes were grouped according to weight classes in order for them to work with weights which they could readily handle. The first week the athletes experimented with the weights until a desirable weight was found. The subjects executed a minimum of eight repetitions and worked to fifteen repetitions through two sets of each lift. When they could handle a weight and perform two sets of fifteen repetitions, the subjects were instructed to add ten pounds of weight and work toward two sets of fifteen repetitions with the heavier resistance.

One workout called for the subjects to go through the gymnastic routine twice. The entire team was divided into seven squads and each squad had a circuit which was different from the others so there would never be more than one squad on a piece of apparatus. Three minutes were allowed for each exercise; at the end of three minutes, a whistle was blown and the squads were instructed to move on to the next exercise.

At the end of each workout, the athletes finished their work by either running sprints, playing touch football, playing soccer, or swimming. The purpose of this was to minimize the mental fatigue and drudgery which accompanies a rigorous training schedule.

Not until the second week in November were the athletes allowed to participate in active wrestling. After the wrestling practices

included active wrestling, the athletes continued in the weight training and gymnastic routine up through the third week in November. After the third week, the entire practice period was spent on wrestling and fundamentals. The conditioning program continued over a period of seven weeks.

Statistical Procedure

This investigator assumed the null hypothesis in analyzing the differences between the initial test (pre-season), re-tests within the experimental group (during and at the end of the season) and the final re-test of each group (six weeks after the conclusion of the season). The null hypothesis states that the frequencies (mean scores) are not different and any difference found would be a result of chance and be unimportant.[1]

The "t" technique for testing the significance of the difference between means derived from uncorrelated groups from small samples was used in the treatment of data of this study. The ratio between the mean difference and the estimate of sampling error of the mean difference is determined by the specific test employed. The ratio was checked for significance in a "t" table with the value of "t" proportional to the degree of freedom (N-1) allowed to determine the relationship between the mean difference and estimate of sampling error of the mean difference. This investigator decided to retain the null hyphothesis at the .01 level of significance.[2]

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[1]Quinn McNemar, Phychological Statistics, (New York: John Wiley and Sons, Inc., 1949), 225.

[2]Ibid., 225.

All data are presented in Appendix B including raw scores, mean differences and steps of the mathematical process employed in the analysis of each area tested.

CHAPTER III

ANALYSIS OF DATA

Introduction

This study was undertaken to determine the effects of a pre-season conditioning program on selected intercollegiate wrestlers compared with a group of non-wrestlers. The subjects were members of the University of North Dakota Wrestling Teams and male students enrolled in required physical education classes at the University of North Dakota

The data collected and compiled in this study were analyzed in this chapter. The analysis was divided into four separate areas: leg strength, back strength, arm strength, and cardiovascular fitness taken from results of the Harvard Step Test. Analysis of the data statistically to determine the significance of the difference between the means of the two groups was the next step taken in the study.

Test Results

LEG STRENGTH

The control group had a mean score of 983.50 pounds in the initial test and a mean score of 1,033.00 pounds in the retest to measure leg strength.

The mean difference between the initial test and the retest of the control group was an increase of 49.50. The estimate of sampling

error of the mean difference was 83.344.

The "t" value of +.59 with 9 degrees of freedom was not significant at the .01 level.

Table 1 shows the initial test and retest scores of the control group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .01 level.

TABLE 1.

MEAN SCORES OF THE CONTROL GROUP IN LEG STRENGTH

Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
10	983.50	1033.00	83.344	49.50	.59 Not Significant

The experimental group in the initial test had a mean score of 1,115.25 pounds and in the retest six weeks after the conclusion of the season had a mean score of 1341.00 pounds. The mean difference of the experimental group between the initial test and retest was an increase of 225.75. The estimate of the sampling error of the mean difference was 65.956. The "t" value of 3.422 with 19 degrees of freedom indicated a significant difference at the .01 level.

Table 2 includes the initial test or pre-season test of the experimental group and retest scores after one month of pre-season conditioning, retest at mid-season, retest at the conclusion of the season and retest six weeks after the conclusion of the season. Mean differences, estimates of sampling error of mean differences and the significance of "t" at .01 level are also included for the experimental group.

TABLE 2

COMPARISTON OF MEAN SCORES OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

Item	Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
1.	20	1115.25	1207.00	47.336	91.75	1.938
					Not Significant	
2.	20	1115.25	1164.75	15.073	44.50	2.952
					Is Significant	
3.	20	1115.25	1211.75	55.634	96.50	1.734
					Not Significant	
4.	20	1115.25	1341.00	65.956	225.75	3.422
					Is Significant	
5.	20	1164.75	1341.00	51.443	176.25	3.426
					Is Significant	
6.	20	1211.75	1341.00	48.883	129.25	2.644
					Not Significant	

Note:

Item 1 refers to the comparison of the Pre-season Test and Retest after one month.

Item 2 refers to the comparison of the Pre-season Test and Retest at Mid-season.

Item 3 refers to the comparison of the Pre-season Test and Retest at the conclusion of the season.

Item 4 refers to the comparison of the Pre-season Test and Retest six weeks after the conclusion of the season.

Item 5 refers to the comparison of the Mid-season Test and Retest six weeks after the conclusion of the season.

Item 6 refers to the comparison of the conclusion of the Season Test and Retest six weeks after the conclusion of the season.

The mean difference between the initial test and the retest of the control group was 49.50 pounds and 225.75 pounds for the experimental group. The difference between the mean differences of the two groups was 176.25 pounds. The estimate of the sampling error for the distribution of differences between the mean differences was 106.284. The

"t" value resulting from the comparison and relationship of the difference between the mean differences and the estimate of the sampling error for the distribution of differences between the mean differences was 1.658. This "t" value with 28 degrees of freedom indicated no significant difference at the .01 level between the mean difference found between the experimental group and the control group. Table 3 shows the significance of the difference between means of the experimental group and control group in leg strength.

TABLE 3

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF UNCORRELATED GROUPS IN LEG STRENGTH

Group	Number	$S_{\bar{D}}$	$\bar{D}$	"t"
Control	10	83.344	49.50	1.658 Not Significant
Experimental	20	65.956	225.75	

BACK STRENGTH

The control group had a mean score of 338.00 pounds in the initial test of back strength and in the retest had a mean score of 325.50 pounds.

Between the initial test and retest of the control group, the mean difference was a decrease of 11.50. The estimate of the sampling error of the mean difference was 17.048. The "t" value of -.674 with 9 degrees of freedom was not significant at the .01 level.

Table 4 shows the initial test and retest scores of the control group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .01 level.

TABLE 4

MEAN SCORES OF THE CONTROL GROUP IN BACK STRENGTH

Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
10	338.00	325.50	17.048	-11.50	-.674 Not Significant

The experimental group had a mean score of 358.75 pounds in the initial test and a mean score of 363.25 pounds in the retest six weeks after the conclusion of the season. The mean difference of the experimental group between the initial test and the retest was an increase of 4.50. The estimate of the sampling error of the mean difference was 14.729. The "t" value of .305 with 19 degrees of freedom indicated no significant difference at the .01 level.

Table 5 includes the pre-season test of the experimental group and retest scores after one month of pre-season conditioning, at mid-season, at the conclusion of the season, and six weeks after the conclusion of the season. Mean differences, estimate of sampling error of mean differences, and the significance of "t" at the .01 level are also included for the experimental group.

Table 5 is found on the following page.

The mean difference between the initial test and retest of the control group was a decrease of 11.50 pounds and for the experimental group an increase of 4.50 pounds. The difference between the mean differences of the two groups was 16.00 pounds. The estimate of the sampling error for the distribution of differences between the mean differences was 22.529. The "t" value from the comparison of the

differences between the mean differences and the estimate of the sampling error for the distribution of differences between the mean differences was .710. This "t" value with 28 degrees of freedom indicated no significant difference at the .01 level between the mean difference found between the experimental group and the control group. Table 6 shows the significance of the difference between means of the experimental group and control group in back strength.

TABLE 5

COMPARISON OF MEAN SCORES OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

Item	Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
1.	20	358.75	354.00	10.915	- 4.75	- .435
					Not Significant	
2.	20	358.75	379.50	11.878	20.75	1.746
					Not Significant	
3.	20	358.75	362.75	10.346	4.00	.386
					Not Significant	
4.	20	358.75	363.25	14.729	4.50	.305
					Not Significant	
5.	20	379.50	363.25	12.090	-16.25	-1.344
					Not Significant	
6.	20	362.75	363.25	8.884	.50	.005
					Not Significant	

TABLE 6

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF UNCORRELATED GROUPS IN BACK STRENGTH

Group	Number	$S_{\bar{D}}$	$\bar{D}$	"t"
Control	10	17.048	-11.50	
				.710
Experimental	20	14.729	4.50	Not Significant

ARM STRENGTH

The mean score of the control group in the initial test of arm strength was 159.50 pounds and in the retest had a mean score of 166.50 pounds.

Between the initial test and retest of the control group, the mean difference was an increase of 7.00. The estimate of the sampling error of the mean difference was 6.333.

The "t" value of 1.105 with 9 degrees of freedom was not significant at the .01 level.

Table 7 shows the initial test and retest scores of the control group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .01 level.

TABLE 7

MEAN SCORES OF THE CONTROL GROUP IN ARM STRENGTH

Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
10	159.50	166.50	6.333	7.00	1.105 Not Significant

The experimental group had a mean score of 144.50 pounds in the initial test and a mean score of 171.75 pounds in the retest six weeks after the conclusion of the season. The mean difference of the experimental group between the initial test and the retest was an increase of 27.25. The estimate of the sampling error of the mean difference was 5.910. The "t" value of 4.610 with 19 degrees of freedom indicated a significant difference at the .01 level.

Table 8 includes the pre-season test of the experimental group and retest scores after one month of pre-season conditioning, at mid-season, at the conclusion of the season, and six weeks after the conclusion of the season. Mean differences, estimate of sampling error of mean differences and the significance of "t" at the .01 level are also included for the experimental group.

TABLE 8

COMPARISON OF MEAN SCORES OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

Item	Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
1.	20	144.50	157.50	5.853	13.00	2.221 Not Significant
2.	20	144.50	154.50	5.392	10.00	1.854 Not Significant
3.	20	144.50	165.50	5.387	21.00	3.898 Is Significant
4.	20	144.50	171.75	5.910	27.25	4.610 Is Significant
5.	20	154.50	171.75	4.508	17.25	3.826 Is Significant
6.	20	165.50	171.75	3.732	6.25	1.674 Not Significant

The mean difference between the initial test and retest of the control group was an increase of 7.00 pounds and for the experimental group an increase of 27.25 pounds. The difference between the mean differences of the two groups was 20.25 pounds. The estimate of the sampling error for the distribution of differences between the mean differences was 27.976. The "t" value from the comparison of the difference between the mean differences and the estimate of the sampling error for the distribution of differences between the mean differences was .723. This "t" value with 28 degrees of freedom indicated

no significant difference at the .01 level between the mean difference found between the experimental group and the control group. Table 9 shows the significance of the difference between means of the experimental group and control group in arm strength.

TABLE 9

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF UNCORRELATED GROUPS IN ARM STRENGTH

Group	Number	$S_{\bar{D}}$	$\bar{D}$	"t"
Control	10	6.333	7.00	.723 Not Significant
Experimental	20	5.910	27.25	

CARDIOVASCULAR FITNESS - THE HARVARD STEP TEST

The mean score of the control group in the initial test of the step test was 85.00 and in the retest the mean score was 82.90.

Between the initial test and retest of the control group, the mean difference was a decrease of 2.10. The estimate of the sampling error of the mean difference was 2.505.

The "t" value of -.838 with 9 degrees of freedom was not significant at the .01 level.

Table 10 shows the initial test and retest scores of the control group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .01 level.

Table 10 is found on the following page.

TABLE 10

MEAN SCORES OF THE CONTROL GROUP IN THE HARVARD STEP TEST

Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
10	85.00	82.90	2.505	-2.10	-.838
					Not Significant

The experimental group had a mean score of 87.50 in the initial test and a mean score of 86.80 in the retest six weeks after the conclusion of the season. The mean difference of the experimental group between the initial test and the retest was a decrease of .70. The estimate of the sampling error of the mean difference was 3.570. The "t" value of -.196 with 19 degrees of freedom indicated no significant difference at the .01 level.

Table 11 includes the pre-season test of the experimental group and retest scores after one month of pre-season conditioning, at mid-season, at the conclusion of the season, and six weeks after the conclusion of the season. Mean difference, estimate of sampling error of mean differences and the significance of "t" at the .01 level are also included for the experimental group.

Table 11 is found on the following page.

The mean difference between the initial test and retest of the control group was a decrease of 2.10 and for the experimental group a decrease of .70. The difference between the mean differences of the two groups was 1.40. The estimate of the sampling error for the distribution of differences between the mean differences was 4.361. The "t" value from the comparison or relationship of the difference

between the mean differences and the estimate of the sampling error for the distribution of differences between the mean differences was .321. This "t" value with 28 degrees of freedom indicated no significant difference at the .01 level between the mean difference found between the experimental group and the control group. Table 12 shows the significance of the difference between means of the experimental group and control group in the Harvard Step Test.

TABLE 11

COMPARISON OF MEAN SCORES OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

Item	Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
1.	20	87.50	102.60	23.041	15.10	.655
						Not Significant
2.	20	87.50	108.55	5.710	21.05	3.686
						Is Significant
3.	20	87.50	92.20	3.764	4.70	1.248
						Not Significant
4.	20	87.50	86.80	3.570	- .70	- .196
						Not Significant
5.	20	108.55	86.80	4.043	-21.75	-5.379
						Not Significant
6.	20	92.20	86.80	2.329	- 5.40	-2.318
						Not Significant

TABLE 12

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF UNCORRELATED GROUPS IN THE HARVARD STEP TEST

Group	Number	$S_{\bar{D}}$	$\bar{D}$	"t"
Control	10	2.505	-2.10	
				.321
Experimental	20	3.570	- .70	Not Significant

Overall, the experimental group improved in all of the areas tested except the test for cardiovascular fitness. The Harvard Step Test results showed a decrease in comparing the pre-season test and the retest six weeks after the conclusion of the season. A decrease of .70 was registered between the mean scores. The "t" score of the experimental group in the Harvard Step Test was not significant at the .01 level.

In arm strength, gains were made by the experimental group from pre-season to the last retest, with an increase of 27.25 pounds recorded by the mean scores. The "t" score of the experimental group in arm strength was significant at the .01 level.

In leg strength, the experimental group showed an increase of 225.75 pounds which was significant at the .01 level.

In back strength, no significant difference was recorded, but the experimental group showed an increase of 4.50 pounds.

The control group did not record a significant difference in any of the areas tested, but did record increases in leg strength and arm strength. Decreases were registered in back strength and cardiovascular fitness between the initial test and retest scores.

CHAPTER IV

DISCUSSION

Preparing athletes for competition has become one of the most perplexing problems facing coaches of present day athletic programs. The knowledge and wisdom needed by the coach to direct a conditioning program must be based upon scientific principles which will benefit and aid the athletes in their efforts to develop superior skill.

In wrestling, the athlete must possess and maintain a physique which is in a continual state of readiness for competition facing him. His body should possess a level of excellence in physical fitness with reserve strength available for his use when the situation demands. An athlete participating in wrestling must have superior strength in his arms, shoulders, back, hips, and legs, as well as the highest attainable level of cardiovascular fitness to increase the efficiency of the body while in competition and to recover from competition.

The pre-season conditioning program conducted at the University of North Dakota was drawn up to condition the selected intercollegiate wrestlers of the University team for the 1965-1966 season. Tests covering leg, back, and arm strength plus cardiovascular fitness were administered at prescribed intervals during the course of the

season to enable study of observable changes in relation to such a program. In initiating the pre-season conditioning program, special attention was directed toward exercises, lifts and drills which would benefit the specific muscle groups of the body which are employed when engaged in active wrestling.

Certain factors must be mentioned at this time in the discussion of this study which are pertinent to the results brought out by the testing program. Of the original eighteen members of the control group, only ten remained enrolled in the University during the second semester. The other eight students either dropped out of school or transferred to other educational institutions. Of the ten students who remained at the University during the second semester, three were freshman students and were required to participate in the national AAHPER Testing Program taken by all freshmen entering the University. Thirty-five wrestlers began the pre-season conditioning program with the test results of fifteen members omitted from the final results because of injury, dropping out of the sport or ineligibility during the course of the season.

Because thirty-three per cent of the control group participated in the AAHPER program, certain limitations on the testing of the group must be explained. Freshman students in physical education participate in conditioning exercises and activities immediately after enrolling in physical education classes. When those students were tested in the selected measures of this study, they were in the middle of the AAHPER Testing Program and any test scores registered by these students would have the strong possibility of having been influenced by the program. In the opinion of this writer, the

participation of thirty-three per cent of the control group in the AAHPER Testing Program may have influenced test scores as well as the comparison of mean scores and mean differences between the control group and the experimental group. These limitations could have affected all phases of the control group's performance in the areas tested by this study.

Before discussing the results of the experimental group in the selected measures of this study, another limitation of the study should be mentioned. In coaching any sport or athlete, the coach stresses and reiterates quite frequently to the athletes concerning the importance of reporting for the beginning of any season in good physical condition. It therefore follows as an uncontrollable factor that some of the wrestlers used as subjects in this study may have done some conditioning during the summer months and may also have reduced body weight to ready themselves for the upcoming season. Therefore, if any of the wrestlers did work out and attempt to ready themselves for the season, the results of the pre-season test might make it more difficult to produce significant improvement. The pre-season test scores could have been higher than scores from a group of athletes who reported for practice but had not worked out previous to the first regularly scheduled testing period.

Leg strength tests were chosen because of the percentage of total time during a match the wrestler spends on his feet as well as the great stress placed on takedowns and maneuvers from the standing position.

The control group registered a mean increase in leg strength of 49.50 pounds during the experimental period extending from October, 1965

to April, 1966. This increase in leg strength was not significant at the .01 level. In the opinion of this writer, the increase shown by the control group in leg strength could have been due to the factors mentioned before regarding the AAHPER Testing Program. In addition, the activities which the control group participated in during the year may have had some affect on the increase of leg strength. These activities included swimming, tumbling, apparatus, tennis, golf, circuit training, volleyball and softball. There is also a slightly remote possibility that some of the increase could be attributed to the maturation of some of the individuals comprising the control group.

The experimental group showed a mean increase in leg strength of 91.75 pounds after one month of pre-season conditioning. Though not significant at the .01 level, the increase in leg strength shown over the pre-season test mean score could have been due to the influence of the conditioning and stress placed upon running and exercises which the wrestlers executed from the standing position. This insignificance was due to the large variance in the performance of the athletes during testing. When tested at mid-season, the experimental group showed a mean decrease of 42.25 pounds compared to the results of the test after one month of pre-season conditioning. This decrease could have been caused by the reduction of the amount of running done during practice and to weight reduction experienced by the athletes in reducing to the desired weight class in which they chose to wrestle during the season.

From mid-season to the conclusion to the season, the experimental group registered a mean increase of 47.00 pounds in leg strength. This increase could have been caused by weight gains experienced by half of the experimental group who did not diet or reduce in weight during the

last two weeks of the season. Comparing the mean score of the test at the conclusion of the season to the mean score of the pre-season test, the experimental group increased in leg strength by 96.50 pounds. This difference was not significant at the .01 level.

In the retest of the experimental group six weeks after the conclusion of the season, an increase in the mean score in leg strength of 129.25 pounds was shown over the mean score of the test at the conclusion of the season. Comparing the mean score of the test six weeks after the conclusion of the season to the mean score of the pre-season test, the experimental group increased in leg strength 225.75 pounds, which was significant at the .01 level. In the opinion of this writer, the large increase of leg strength shown by the experimental group could have been partly due to the mental attitude of the wrestlers toward the sport after such a long period of time when they had to maintain careful watch over their weight and adhere strictly to training rules. After training such a long period of time, it seems possible that the wrestler would no longer watch his diet.

In back strength, the control group showed a mean decrease of 12.50 pounds from the beginning of the experimental period until it ended. This decrease could have been attributed to a number of factors. The fact that part of the control group was included in the AAHPER program could have raised the initial test mean score to a higher reading, bringing about the subsequent decrease in mean scores. Also, the nature of activities in which the group participated during the course of the year may not have strengthened the back.

The experimental group, after one month of pre-season conditioning, decreased in back strength from the mean score of the pre-season test by 4.75 pounds. This difference was not significant at the .01 level.

At mid-season, the back strength of the experimental group increased over the mean score of the test after one month of pre-season conditioning by 25.50 pounds. Comparing the mean score of the mid-season test when the peak of back strength was reached to the mean score of the pre-season test, an increase of 20.75 pounds was registered. This increase was not significant at the .01 level. The increase observed at mid-season could have been attributed to the bridging drills and exercises designated to build up the neck and back musculature of the wrestlers, which is used as the principal axis in the execution of moves.

From mid-season to the conclusion of the season, the mean difference in back strength decreased 16.75 pounds. In comparing the mean back strength at the conclusion of the season to the mean score of the pre-season test, the difference was an increase of only 4.00 pounds. This was not significant at the .01 level. This decrease from mid-season to the conclusion of the season could have been caused by the change in workout routines followed during the last half of the season.

In arm strength, the control group had a mean increase of 7.00 pounds from the beginning of the experimental period until it ended. This increase was not significant at the .01 level and the gain in arm strength, in the opinion of this writer, could have been attributed to the constant use of the dominant arm in activities which were participated in during the course of the year.

The experimental group had a mean increase of 13.00 pounds in arm strength between the pre-season test and the retest after one month of pre-season conditioning. Though not significant at the .01 level, this increase could have been caused by the conditioning program.

A non-significant decrease of 3.00 pounds in arm strength was registered on the mid-season test from the mean score after one month of pre-season conditioning. However, this mean score of the mid-season test was still 10.00 pounds above the mean score of the pre-season test.

Between the mid-season test and retest at the conclusion of the season, a mean increase in arm strength of 11.00 pounds was registered by the experimental group. This mean score of the test at the conclusion of the season was significant at the .01 level when compared to the mean score of the pre-season test. An overall mean increase of 21.00 pounds was recorded in arm strength over this period of twenty-two weeks. This increase, in the opinion of this writer, could have been caused by the weight gains made by half of the experimental group during the last two weeks of the season. These athletes had finished their competition and helped to prepare the remaining varsity wrestlers for the national tournament the last week of the season. Some of the gains may also have been caused by the psychological preparation made by the varsity wrestlers in preparing themselves for this tournament. Because the tournament concluded the season, many of the wrestlers wanted to be in top physical condition when participating in this tournament.

A significant increase in arm strength at the .01 level was recorded comparing the mean scores of the pre-season test and retest six weeks after the conclusion of the season. A mean increase of 27.25 pounds was registered in arm strength by the experimental group. Numerous factors could have caused this increase to take place. In the opinion of this writer, a combination of the effects of the

pre-season conditioning exercises coupled with gains made in body weight, rest and constant use of the upper appendages of the body could possibly have increased the strength and power of the athlete.

The significance of the pre-season conditioning program participated in by the experimental group is shown by the increases in leg and arm strength, even though the mean differences were not significant at the .01 level when compared to the mean differences of the control group. Brown and Riley[1] conducted a similar experiment and the experimental group (weight training group) showed significant increases over the control group in leg strength and vertical jump. Chui[2] studied the effects of weight training on athletic power and pound that the weight training group showed more consistent increases in all areas than did the control group. Capen's[3] findings coincided with those of Chui in that weight training did not cause muscular tightness nor did it slow down muscle contraction. In comparing the conclusions of the study conducted by this writer and the conclusions and finding of the studies of Brown and Riley, Chui and Capen, a pre-season conditioning program of weight training, isometrics and conditioning exercises does produce favorable results as evidenced by the testing conducted throughout the course of this experiment. A program of this nature, in the opinion of this writer, should become a part of any team's preparation for a season of competition.

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[1]Robert J. Brown and Douglas R. Riley, "The Effect of Weight Training on Leg Strength and the Vertical Jump," (unpublished Master's thesis, Springfield College, 1957).

[2]Edward Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, XXI (October, 1950), 188-194.

[3]Edward K. Capen, "The Effect of Systematic Weight Training on Power, Strength, and Endurance," Research Quarterly, XXI (May, 1950), 83-93.

The Harvard Step Test[4] was chosen as a test for cardiovascular fitness to determine a circulo-respiratory state of readiness for strenuous activity. The coaches of the University of North Dakota Wrestling Teams were particularly interested in this phase of the testing program to see if the individual athletes involved in the testing would improve their cardiovascular state of fitness. Wrestling is a very strenuous activity which demands a superior level of cardiovascular fitness from the athlete if he is to participate in the sport without any ill effects.

The Harvard Step Test requires the subject to step up onto and down from a bench thirty inches in height for a continuous period of five minutes. The subjects are then seated, and pulse count taken during intervals of thirty seconds and between one minute to a minute and a half, two minutes to two and a half minutes, and three minutes to three and a half minutes after completion of the five minute exercise period. The total of the pulse count is then taken and substituted into the following formula:

$$\text{Physical Efficiency Index} = \frac{\text{Duration of Exercise in Seconds (300)} \times 100}{2 \times \text{Sum of Pulse Counts in Recovery}}$$

The quotient obtained from the formula was then compared to the norms established for the Harvard Step Test. The lower the quotient, the poorer the physical efficiency of the subject and the larger the quotient, the better the physical efficiency of the subject is to compensate for strenuous exercise.

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[4]H. Harrison Clarke, Application of Measurement to Health and Physical Education. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1961.

In the Harvard Step Test, the control group decreased 2.10 in the mean score between the initial test and retest during the course of the experimental period lasting seven months. This decline could have been caused by the participation of thirty-three per cent of the control group in the AAHPER Testing Program. Their participation could have affected the mean of the initial test, causing the mean to be higher than if the subjects had not participated in this program. Another factor, which could have possibly caused the decrease to occur, had to do with the types of activities in which the subjects were enrolled during the course of the year. These activities may not have placed great stress on the cardiovascular system.

The experimental group improved in the Harvard Step Test after one month of pre-season conditioning by 15.10 over the mean score of the pre-season test. Although not significant at the .01 level, the group did have a mean score in cardiovascular fitness which was rated as excellent by the norms of the Harvard Step Test.

An increase of 5.95 was recorded in the mean difference comparing the mid-season test and the test after one month of pre-season conditioning. The peak of cardiovascular fitness was reached during the mid-season test and could have been due to the strenuous workouts the wrestlers participated in during the first half of the season. A mean increase of 21.05 between the pre-season test and retest at mid-season was recorded. This increase was the largest during the experimental period and was significant at the .01 level.

After mid-season, a decrease in cardiovascular fitness from the mean score of this test to the mean score of the retest at the conclusion of the season amounted to 16.35. This period of time covered

two months, and was the part of the season when the coaching staff varied the workout routine of the team to avoid mental fatigue and staleness of the wrestlers. However, the mean score at the conclusion of the season was 4.70 above the mean score of the pre-season test, though not significant at the .01 level.

A mean decrease of 5.40 in cardiovascular fitness from the conclusion of the season to six weeks after the conclusion of the season was recorded by the experimental group. In comparing the mean of the six weeks retest after the conclusion of the season to the pre-season test, the experimental group had a mean decrease of .70. In the opinion of this writer, this decrease could be attributed to some uncontrollable factors. Some of the athletes could have been working out in advance of the pre-season conditioning program and higher scores in the Harvard Step Test would have been recorded, thereby distorting the initial mean score as well as the mean differences in comparing with other test scores.

Peters[5] investigated the effects of a pre-season conditioning program on hockey players and also found that the cardiovascular fitness of the athletes reached its peak during the season and then declined after the conclusion of the season.

In the opinion of this writer, a critical analysis of coaching techniques should be conducted to maintain the level of cardiovascular fitness over the entire season and prevent this level from dropping off as sharply as it did in this study and in that of hockey players by Peters.

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[5]Robert H. Peters, "An Investigation of Certain Effects of a Pre-Season Conditioning Program of Selected Intercollegiate Ice Hockey Players at Various Times Before, During, and After the Playing Season," (unpublished individual research paper, Department of Physical Education, University of North Dakota, 1964).

Overall, the pre-season conditioning program conducted by this writer during the 1965 wrestling season should not be measured in terms of success in matches won or lost during the season. Instead it should be judged on the results of the testing conducted for strength retention throughout the course of the season.

The experimental group did have gains in leg, back and arm strength when comparing the mean scores of the pre-season test with that of the retest six weeks after the conclusion of the season. The athletes experienced the largest gain in leg strength amounting to 225.75 pounds. Arm strength gains amounted to 27.25 pounds and back strength showed the smallest gain of 4.50 pounds. Cardiovascular fitness was the only area in which the experimental group did not improve.

The control group improved in two areas tested, leg strength and arm strength. Decreases were experienced in back strength and cardiovascular fitness. Mean increases amounted to 49.50 pounds in leg strength, and 7.00 pounds in arm strength over the course of the entire experimental period. Decreases in back strength were 12.50 pounds and in cardiovascular fitness amounted to 2.10 on the Harvard Step Test.

The true merits of the pre-season conditioning program could be based upon the comparison of the mean increases or decreases of the experimental or control group in the respective areas tested throughout the duration of the experimental period.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The thirty subjects selected for this study were male students at the University of North Dakota, Grand Forks, North Dakota. The experimental group was composed of selected intercollegiate wrestlers of the varsity and freshman teams at the University of North Dakota participating in the intercollegiate sport for twenty-one weeks, practicing five days a week. The subjects participated in a pre-season conditioning program, five days a week, for a period of eight weeks. The control group consisted of students who participated in the service program classes of the Physical Education Department of the University of North Dakota. The experimental group was tested at intermittent intervals during the course of the season. Tests of leg, arm and back strength plus a test for cardiovascular fitness were administered. These tests were administered at the start of the pre-season conditioning program, one month after pre-season conditioning, at mid-season, at the conclusion of the season and six weeks after the conclusion of the season. The control group was administered similar tests at the start of pre-season conditioning and six weeks after the conclusion of the season.

The experimental group was compared to the control group and intra-squad comparison of the experimental group's scores were made to determine whether any significant changes occurred in the specific areas tested.

The null hypothesis was assumed with respect to the differences between the means of the experimental and control group and within the experimental group. This hypothesis was tested with the "t" technique for the difference between means derived from uncorrelated scores and correlated scores from small samples.

Conclusions

From this study the following conclusions seem warranted on the basis of the data collected.

1. The experimental group increased in leg strength one month after pre-season conditioning began and showed a decrease at mid-season but increased steadily until six weeks after the conclusion of the season when the highest mean scores were recorded. The greatest gains in the study were recorded in leg strength.

2. In back strength, the experimental group declined after one month of conditioning and reached its peak at mid-season and then declined until the conclusion of the season. The post season mean score was higher than the mean score of the pre-season test.

3. The experimental group increased in arm strength one month after pre-season conditioning began, then declined the remainder of the season. The pre-season mean score was higher than the post season mean score.

4. The cardiovascular fitness of the experimental group improved until mid-season and then declined. The pre-season mean score was

higher than the post season mean score.

5. The control group recorded no significant changes in the selected measures, but showed increases in leg strength and arm strength. Back strength and cardiovascular fitness declined from the mean scores recorded during the pre-season test.

6. The pre-season conditioning program carried on for eight weeks did produce significant changes in arm strength and leg strength of the experimental group. An increase in back strength was recorded, but was not significant at the .01 level. The Harvard Step Test results used as a measure of cardiovascular fitness were not significant as well.

Recommendations

After conducting this study, it is recommended by this writer that further study and investigation be conducted to compare the changes observed in relation to various forms of conditioning on wrestlers and non-wrestlers at intervals of varying degree before, during and following the training season.

It is recommended that a deconditioning program become an established practice of every coach's plan in handling an athletic team. This could minimize the fluctuations of cardiovascular fitness experienced by the athletes during this study. By employing a deconditioning program, it would be possible to alleviate the stress to the cardiovascular system and prevent the athletes from losing a state of fitness which they had worked to attain during the season.

It is further recommended that studies be undertaken to evaluate the effectiveness of similar pre-season conditioning programs. This would probably require investigations over a longer period of time and would also require employing different conditioning practices in wrestling

as well as other sports requiring a high level of fitness. Studies of this type would enable coaches to incorporate those conditioning practices which would contribute most toward the desired level of conditioning.

CONDITIONING AND STRETCHING ROUTINE

The following exercises were followed for loosening up before each practice session during the pre-season conditioning program.

1. Jog in place from two to three minutes.

2. Side straddle hop or jumping jacks.

3. Trunk twister. Wrestlers assumed an upright position with feet spread width of shoulders; then rotated upper body to right and to left.

4. Toe toucher. Wrestlers assumed upright position with feet shoulder width apart, on command right hand was touched to left toe, left hand to right toe, etc.

5. Leg lifts in prone position. Wrestlers assumed a prone position and on the command lifted both legs simultaneously to a height of six inches from the floor, spread them apart shoulder width level, returned legs together six inches above floor, raised legs six inches more above the floor keeping the legs straight during the entire exercise; repeat exercise performed at first level; then lower legs and feet to floor.

6. Isometric push-ups with partner. One wrestler performed a regular push-up while partner placed his hands upon his back and exerted pressure when the other wrestler attempted to straighten his arms during the push-up.

7. Isometric sit-ups with partner. One wrestler performed a regular sit-up in the bent knee position while his partner placed his hands upon his chest and exerted pressure when the other wrestler attempted to perform the sit-up.

8. Isometric prone back-arch exercise. Wrestlers assumed a prone position with legs straight and together, arms folded across chest. On

command, the wrestler attempted to lift his entire body off the floor by exerting force through his neck and legs. This position was held for a ten second period of time.

9. Extension push-ups. The wrestler assumed a supine position with his arms extended straight out from the shoulder above the head. On the command, the wrestler attempted to execute a straight arm push-up and hold himself clear of the floor for a period of time varying from five seconds to ten seconds.

10. Six count agility drill. Wrestler assumed a standing psotion, went to a squat position, extended his legs backward to a front leaning position, does a sitout to the right, returns to a front leaning position, returns to the squat position, and then to the standing position to complete the exercise.

11. Back push-ups. The wrestler assumed a prone position, and on the command performed a back push-up by placing his hands on the floor immediately above the shoulders and executing a back bend and lifting the body off the floor.

12. Hurdle exercise for stretching. Wrestler assumed a sitting position on the floor, extended one leg straight out in front of them, the other leg tucked up behind him; each wrestler attempted to bend forward and touch his nose on his knee of the leg extended in front of him.

WEIGHT TRAINING PROGRAM

The following lifts were used during the pre-season conditioning program. The athletes executed a minimum of eight repetitions and worked to fifteen repetitions through two sets of each lift. When they could handle a weight and perform two sets of fifteen repetitions, the subjects were instructed to add ten pounds of weight and work toward two sets of fifteen repetitions with the heavier resistance.

1. Military press
2. Regular and reverse curls
3. Straight arm pullover
4. Lateral dumbbell raises
5. Bench press
6. Upright rowing
7. Straight arm dead lift
8. Bent arm supine lateral raise
9. Wrist curls (regular and reverse)

GYMNASTIC ROUTINE

The entire team was divided into seven squads and each squad was given a circuit which was different from the others. Three minutes were allowed for each exercise; at the end of three minutes a whistle was blown and the squads were instructed to move on to the next exercise. The following routine was used for gymnastic exercises.

1. Climb twenty foot rope with hands only
2. Pull-ups; ten to a set
3. Skin the Cat on the still rings; five times to a set
4. Horizontal ladder; once through and back again at a bent arm position to each set
5. Bar dips on parallel bars; ten to a set
6. Leg lifts on the stall bars; ten to a set
7. Hand stand and walk on hands fifteen feet
8. Hand stand push-ups against wall, five to a set
9. Isometric resistance exercise on neck; four ways to each set
10. Peg board; once through to a set according to the numbers on the peg board

INITIAL TEST AND RETEST OF CONTROL GROUP IN LEG STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	820	1190	370	136900
2.	790	960	170	28900
3.	865	840	- 25	625
4.	725	740	15	225
5.	1270	760	-510	260100
6.	950	840	-110	12100
7.	900	1130	230	52900
8.	1230	1080	-150	22500
9.	1445	1760	315	99225
10.	840	1030	190	36100
	9835	10330	+495	649575

Mean Score of Initial Test	983.50
Mean Score of Retest	1033.00
Sum of the Differences	+495
Sum of Difference Squared	649575

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Control

N = 10

D = +495

D^2 = 649575

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{649575 - \frac{(+495)^2}{10}}}{10 - 1}$$

$\sqrt{N}$ $\sqrt{10}$

$S_{\bar{D}}$ = 83.344

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{+495}{10}$ = 49.5

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{+49.5}{83.344} = +.59$

df = N - 1 = 10-1 = 9

"t" at .01 level = 3.250

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AFTER ONE MONTH OF PRE-SEASON CONDITIONING OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	1000	1290	290	84100
2.	710	1060	350	122500
3.	980	1300	320	102400
4.	1370	1520	150	22500
5.	1100	1400	300	90000
6.	990	1190	200	40000
7.	1010	840	- 170	28900
8.	1310	1240	- 70	4900
9.	790	730	- 60	3600
10.	1140	1070	- 70	4900
11.	1790	1690	- 100	10000
12.	850	1020	170	28900
13.	1080	1200	120	14400
14.	1330	1335	5	25
15.	1280	1200	- 80	6400
16.	1090	980	- 110	12100
17.	930	1550	620	384400
18.	1100	995	- 105	11025
19.	1115	1000	- 115	13225
20.	1340	1530	190	36100
	22305	24140	+1835	1017975

Mean Score of Pre-Season Test	1115.25
Mean Score of Retest After One Month	1207
Sum of Differences	1835
Sum of Differences Squared	1017975

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

N = 20

D = +1835

D^2 = 1017975

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{1017975 - \frac{(1835)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 47.336

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{+1835}{20}$ = +91.75

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{91.75}{47.336} = 1.938$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT MID-SEASON

OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	1000	1010	10	100
2.	710	1180	470	220900
3.	980	945	- 35	1225
4.	1370	1470	100	10000
5.	1100	1440	340	115600
6.	990	1145	155	24025
7.	1010	1325	315	99225
8.	1310	1490	180	32400
9.	790	620	- 170	28900
10.	1140	960	- 180	32400
11.	1790	1730	- 60	3600
12.	850	880	30	900
13.	1080	1170	- 10	100
14.	1330	1290	- 40	1600
15.	1280	1110	- 170	28900
16.	1090	1200	110	12100
17.	930	1330	400	160000
18.	1100	870	- 230	52900
19.	1115	840	- 275	75625
20.	1340	1290	- 50	2500
	22305	23295	+ 890	903000

Mean Score of Pre-Season Test	1115.25
Mean Score of Retest at Mid-Season	1164.75
Sum of Differences	890
Sum of Differences Squared	903000

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

N = 20

D = +890

D^2 = 903000

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{903000 - \frac{(890)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 15.073

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{890}{20}$ = 44.5

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{44.5}{15.073} = 2.952$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

PRE-SEASON TEST AND RETEST AT THE CONCLUSION OF THE SEASON

OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	1000	1190	190	36100
2.	710	1155	445	198025
3.	980	1000	20	400
4.	1370	1700	330	108900
5.	1100	1370	270	72900
6.	990	1240	250	62500
7.	1010	1260	250	62500
8.	1310	1140	- 170	28900
9.	790	780	- 10	100
10.	1140	1240	100	10000
11.	1790	1280	- 510	260100
12.	850	820	- 30	900
13.	1080	1350	270	72900
14.	1330	1390	60	3600
15.	1280	1330	50	2500
16.	1090	1160	70	4900
17.	930	1460	530	280900
18.	1100	800	- 300	90000
19.	1115	890	- 225	50625
20.	1340	1680	340	115600
	22305	24235	+1930	1362350

Mean Score of Pre-Season Test 1115.25

Mean Score of Retest at Conclusion of Season 1211.75

Sum of Differences 1930

Sum of Differences Squared 1362350

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

N = 20

D = +1930

D^2 = 1362350

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{1362350 - \frac{(1930)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 55.634

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{1930}{20}$ = 96.5

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{96.5}{55.634} = 1.734$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	1000	1510	510	260100
2.	710	1370	660	435600
3.	980	1220	240	57600
4.	1370	1870	500	250000
5.	1100	1400	300	90000
6.	990	1390	400	160000
7.	1010	1230	220	48400
8.	1310	1320	10	100
9.	790	790	0	0
10.	1140	870	- 270	72900
11.	1790	1940	150	22500
12.	850	1000	150	22500
13.	1080	1290	210	44100
14.	1330	1320	- 10	100
15.	1280	1420	140	19600
16.	1090	1070	- 20	400
17.	930	1640	710	504100
18.	1100	1070	- 30	900
19.	1115	950	- 165	27225
20.	1340	2150	810	656100
	22305	26820	+4515	2672225

Mean Score of Initial Test	1115.25
Mean Score of Retest Six Weeks After The Conclusion of The Season	1341
Sum of Differences	4515
Sum of Differences Squared	2672225

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

N = 20

D = 4515

D^2 = 2672225

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{2672225 - \frac{(4515)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}}$$

$$\frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 65.956

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{4515}{20}$ = 225.75

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{225.75}{65.956} = 3.422$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

MID-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	Mid-Season Test	Six Weeks Test	Sum of Difference	Difference Squared
1.	1010	1510	400	160000
2.	1180	1370	190	36100
3.	945	1220	275	75625
4.	1470	1870	400	160000
5.	1440	1400	- 40	1600
6.	1145	1390	245	60025
7.	1325	1230	- 95	9025
8.	1490	1320	- 170	28900
9.	620	790	170	28900
10.	960	870	- 90	8100
11.	1730	1940	210	44100
12.	880	1000	120	14400
13.	1170	1290	120	14400
14.	1290	1320	30	900
15.	1110	1420	310	96100
16.	1200	1070	- 30	900
17.	1330	1640	310	96100
18.	870	1070	200	40000
19.	840	950	110	12100
20.	1290	2150	860	739600
	23295	26820	+3525	1626875

Mean Score of Mid-Season Test	1164.75
Mean Score of Test Six Weeks After The Conclusion of The Season	1341
Sum of Differences	3525
Sum of Differences Squared	1626875

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

N = 20

D = 3525

D^2 = 1626875

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{1626875 - \frac{(3525)^2}{20}}}{20 - 1}$$

$$\frac{\sqrt{N}}{\sqrt{20}}$$

$S_{\bar{D}}$ = 51.443

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{3525}{20}$ = 176.25

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{176.25}{51.443} = 3.426$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

CONCLUSION OF THE SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN LEG STRENGTH

	End of Season Test	Six Weeks Retest	Sum of Difference	Difference Squared
1.	1190	1510	320	102400
2.	1155	1370	215	46225
3.	1000	1220	220	48400
4.	1700	1870	170	28900
5.	1370	1400	30	900
6.	1240	1390	150	22500
7.	1260	1230	- 30	900
8.	1140	1320	180	32400
9.	780	790	10	100
10.	1240	870	- 370	136900
11.	1280	1940	660	435600
12.	820	1000	180	32400
13.	1350	1290	- 60	3600
14.	1390	1320	- 70	4900
15.	1330	1420	90	8100
16.	1160	1070	- 90	8100
17.	1460	1640	180	32400
18.	800	1070	270	72900
19.	890	950	60	3600
20.	1680	2150	470	220900
	24235	26820	+2585	1242125

Mean Score of End of Season Test 1211.75

Mean Score of Retest Six Weeks After The Conclusion of the Season 1341

Sum of Differences 2585

Sum of Differences Squared 1242125

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Leg Strength GROUP Experimental

$N = 20$

$D = 2585$

$D^2 = 1242125$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \dfrac{S_D}{\sqrt{N}} =$

$$\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N - 1}} \qquad \sqrt{\frac{1242125 - \frac{(2585)^2}{20}}{20 - 1}}$$

$$\sqrt{N} \qquad \sqrt{20}$$

$S_{\bar{D}} = 48.883$

$\bar{D}$ (Mean Difference) $= \dfrac{D}{N} = \dfrac{2585}{20} = 129.25$

$t = \dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{129.25}{48.883} = 2.644$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

INITIAL TEST AND RETEST OF CONTROL GROUP IN BACK STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	250	270	20	400
2.	380	310	- 70	4900
3.	315	280	- 35	1225
4.	310	280	- 30	900
5.	380	290	- 90	8100
6.	360	400	40	1600
7.	345	430	95	9025
8.	310	300	- 10	100
9.	430	395	- 35	1225
10.	300	300	0	0
	3380	3255	-115	27475

Mean Score of Initial Test	338.00
Mean Score of Retest	325.50
Sum of Difference	-115
Sum of Difference Squared	27475

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Control

N = 10

D = -115

D^2 = 27475

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{27475 - \frac{(-115)^2}{10}}}{10 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{10}}$$

$S_{\bar{D}}$ = 17.048

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-115}{10}$ = -11.5

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-11.5}{17.048} = -.674$

df = N - 1 = 10 - 1 = 9

"t" at .01 level = 3.250

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AFTER ONE MONTH OF PRE-SEASON CONDITIONING OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	410	450	40	1600
2.	340	435	95	9025
3.	430	400	- 30	900
4.	430	430	0	0
5.	360	330	- 30	900
6.	290	300	10	100
7.	260	330	70	4900
8.	340	305	- 35	1225
9.	225	220	- 5	25
10.	320	350	30	900
11.	490	475	- 15	225
12.	290	295	5	25
13.	450	340	-110	12100
14.	400	370	- 30	900
15.	300	290	- 10	100
16.	320	290	- 30	900
17.	330	380	50	2500
18.	410	340	- 70	4900
19.	330	270	- 60	3600
20.	450	480	30	900
	7175	7080	- 95	45725

Mean Score of Pre-Season Test	358.75
Mean Score of Retest After One Month	354
Sum of Differences	-95
Sum of Differences Squared	45725

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = -95

D^2 = 45725

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{45725 - \frac{(-95)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}}$$

$$\frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 10.915

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-95}{20}$ = -4.75

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-4.75}{10.915} = -.435$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT MID-SEASON

OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	410	460	50	2500
2.	340	330	- 10	100
3.	430	420	- 10	100
4.	430	470	40	1600
5.	360	350	- 10	100
6.	290	420	130	16900
7.	260	390	130	16900
8.	340	450	110	12100
9.	225	200	- 25	625
10.	320	340	20	400
11.	490	470	- 20	400
12.	290	310	20	400
13.	450	420	- 30	900
14.	400	410	10	100
15.	300	340	40	1600
16.	320	290	- 30	900
17.	330	380	50	2500
18.	410	430	20	400
19.	330	270	- 60	3600
20.	450	440	- 10	100
	7175	7590	+ 415	62225

Mean Score of Pre-Season Test	358.75
Mean Score of Mid-Season Retest	379.5
Sum of Differences	+415
Sum of Differences Squared	62225

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = 415

D^2 = 62225

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{62225 - \frac{(415)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 11.878

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{415}{20}$ = 20.75

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{20.75}{11.878} = 1.746$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT THE CONCLUSION OF THE SEASON

OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	410	440	30	900
2.	340	350	10	100
3.	430	420	- 10	100
4.	430	430	0	0
5.	360	370	10	100
6.	290	310	20	400
7.	260	370	110	12100
8.	340	320	- 20	400
9.	225	210	- 15	225
10.	320	300	- 20	400
11.	490	450	- 40	1600
12.	290	325	35	1225
13.	450	350	-100	10000
14.	400	390	- 10	100
15.	300	315	15	225
16.	320	330	10	100
17.	330	330	0	0
18.	410	430	20	400
19.	330	270	- 60	3600
20.	450	545	95	9025
	7175	7255	+ 80	41000

Mean Score of Pre-Season Test	358.75
Mean Score of Retest at The Conclusion of The Season	362.75
Sum of Differences	+80
Sum of Differences Squared	41000

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = +80

D^2 = 41000

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{41000 - \frac{(80)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 10.3468

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{80}{20}$ = 4.00

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{4.00}{10.346} = .38662$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	Initial Test	Retest	Sum of Difference	Differences Squared
1.	410	440	30	900
2.	340	360	20	400
3.	430	395	- 35	1225
4.	430	450	20	400
5.	360	310	- 50	2500
6.	290	370	80	6400
7.	260	400	140	19600
8.	340	350	10	100
9.	225	190	- 35	1225
10.	320	320	0	0
11.	490	500	10	100
12.	290	320	30	900
13.	450	320	-130	16900
14.	400	360	- 40	1600
15.	300	340	40	1600
16.	320	250	- 70	4900
17.	330	350	20	400
18.	410	360	- 50	2500
19.	330	290	- 40	1600
20.	450	590	140	19600
	7175	7265	+ 90	82850

Mean Score of Pre-Season Test	358.75
Mean Score of Retest Six Weeks After The Conclusion of The Season	363.25
Sum of Differences	+90
Sum of Differences Squared	82850

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = +90

D^2 = 82850

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{82850 - \frac{(90)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 14.7298

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{90}{20}$ = 4.50

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{4.50}{14.729} = .305$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

MID-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	Mid-Season Test	Six Weeks Test	Sum of Difference	Difference Squared
1.	460	440	- 20	400
2.	330	360	30	900
3.	420	395	- 25	625
4.	470	450	- 20	400
5.	350	310	- 40	1600
6.	420	370	- 50	2500
7.	390	400	10	100
8.	450	350	-100	10000
9.	200	190	- 10	100
10.	340	320	- 20	400
11.	470	500	30	900
12.	310	320	10	100
13.	420	320	-100	10000
14.	410	360	- 50	2500
15.	340	340	0	0
16.	290	250	- 40	1600
17.	380	350	- 30	900
18.	430	360	- 70	4900
19.	270	290	20	400
20.	440	590	150	22500
	7590	7265	-325	60825

Mean Score of Mid-Season Test	379.5
Mean Score of Test Six Weeks After The Conclusion of The Season	363.25
Sum of Differences	-325
Sum of Differences Squared	60825

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = -325

D^2 = 60825

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{60825 - \frac{(-325)^2}{20}}}{20 - 1}$$

$\sqrt{N}$ $\sqrt{20}$

$S_{\bar{D}}$ = 12.090

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-325}{20}$ = -16.25

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-16.25}{12.090} = -1.344$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

CONCLUSION OF THE SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN BACK STRENGTH

	End of Season Test	Six Weeks Retest	Sum of Difference	Difference Squared
1.	440	440	0	0
2.	350	360	10	100
3.	420	395	-25	625
4.	430	450	20	400
5.	370	310	-60	3600
6.	310	370	60	3600
7.	370	400	30	900
8.	320	350	30	900
9.	210	190	-20	400
10.	300	320	20	400
11.	450	500	50	2500
12.	325	320	- 5	25
13.	350	320	-30	900
14.	390	360	-30	900
15.	315	340	25	625
16.	330	250	-80	6400
17.	330	350	20	400
18.	430	360	-70	4900
19.	270	290	20	400
20.	545	590	45	2025
	7255	7265	+10	30000

Mean Score of End of Season Test	362.75
Mean Score of Retest Six Weeks After The Conclusion of The Season	363.25
Sum of Differences	+10
Sum of Differences Squared	30000

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Back Strength GROUP Experimental

N = 20

D = +10

D^2 = 30000

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N - 1}} \qquad \sqrt{\frac{30000 - \frac{(10)^2}{20}}{20 - 1}}$$

$$\sqrt{N} \qquad \sqrt{20}$$

$S_{\bar{D}}$ = 8.8846

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{10}{20}$ = .50

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{.50}{8.884} = .00562$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

INITIAL TEST AND RETEST OF CONTROL GROUP IN ARM STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	125	130	5	25
2.	165	180	15	225
3.	150	140	-10	100
4.	185	160	-25	625
5.	150	165	15	225
6.	170	190	20	400
7.	170	180	10	100
8.	165	145	-20	400
9.	180	220	40	1600
10.	135	155	20	400
	1595	1665	+70	4100

Mean Score of Initial Test	159.50
Mean Score of Retest	166.50
Sum of Difference	+70
Sum of Difference Squared	4100

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Control

N = 10

D = +70

D^2 = 4100

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{4100 - \frac{(70)^2}{10}}}{10 - 1}$$

$\sqrt{N}$

$\sqrt{10}$

$S_{\bar{D}}$ = 6.33364

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{70}{10}$ = 7.00

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{7.00}{6.334} = 1.105$

df = N - 1 = 9

"t" at .01 level = 3.250

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AFTER ONE MONTH OF PRE-SEASON CONDITIONING OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	100	140	40	1600
2.	125	155	30	900
3.	105	190	85	7225
4.	165	190	25	625
5.	150	135	- 15	225
6.	140	130	- 10	100
7.	175	170	- 5	25
8.	140	145	5	25
9.	120	165	45	2025
10.	125	140	15	225
11.	150	150	0	0
12.	140	175	35	1225
13.	180	160	- 20	400
14.	220	195	- 25	625
15.	105	125	20	400
16.	155	155	0	0
17.	120	145	25	625
18.	160	170	10	100
19.	135	140	5	25
20.	180	175	- 5	25
	2890	3150	+260	16400

Mean Score of Pre-Season Test	144.50
Mean Score of Retest After One Month	157.50
Sum of Differences	260
Sum of Differences Squared	16400

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

$N = 20$

$D = +260$

$D^2 = 16400$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \dfrac{S_D}{\sqrt{N}} =$

$$\sqrt{\frac{\Sigma D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{16400 - \frac{(260)^2}{20}}{20-1}}$$

$$\sqrt{N} \qquad \sqrt{20}$$

$S_{\bar{D}} = 5.85353$

$\bar{D}$ (Mean Difference) $= \dfrac{D}{N} = \dfrac{260}{20} = 13.00$

$t = \dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{13.00}{5.853} = 2.221$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT MID-SEASON

OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	100	140	40	1600
2.	125	125	0	0
3.	105	160	55	3025
4.	165	195	30	900
5.	150	140	- 10	100
6.	140	140	0	0
7.	175	175	0	0
8.	140	150	10	100
9.	120	145	25	625
10.	125	160	35	1225
11.	150	140	- 10	100
12.	140	135	- 5	25
13.	180	165	- 15	225
14.	220	195	- 25	625
15.	105	115	10	100
16.	155	160	5	25
17.	120	185	65	4225
18.	160	150	- 10	100
19.	135	140	5	25
20.	180	175	- 5	25
	2890	3090	+200	13050

Mean Score of Pre-Season Test	144.50
Mean Score of Retest at Mid-Season	154.50
Sum of Differences	200
Sum of Differences Squared	13050

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

$N = 20$

$D = +200$

$D^2 = 13050$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \dfrac{S_D}{\sqrt{N}} =$

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{13050 - \frac{(200)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}} = 5.39244$

$\bar{D}$ (Mean Difference) $= \dfrac{D}{N} = \dfrac{200}{20} = 10.00$

$t = \dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{10.00}{5.392} = 1.854$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT THE CONCLUSION OF THE SEASON

OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	100	160	60	3600
2.	125	155	30	900
3.	105	180	75	5625
4.	165	215	50	2500
5.	150	160	10	100
6.	140	160	20	400
7.	175	165	- 10	100
8.	140	150	10	100
9.	120	150	30	900
10.	125	145	20	400
11.	150	160	10	100
12.	140	145	5	25
13.	180	155	- 25	625
14.	220	230	10	100
15.	105	130	25	625
16.	155	180	25	625
17.	120	165	45	2025
18.	160	150	- 10	100
19.	135	165	30	900
20.	180	190	10	100
	2890	3310	+420	19850

Mean Score of Pre-Season Test	144.50
Mean Score of Retest at Conclusion of Season	165.50
Sum of Differences	420
Sum of Differences Squared	19850

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

N = 20

D = +420

D^2 = 19850

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{19850 - \frac{(420)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 5.38774

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{420}{20}$ = 21.00

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{21.00}{5.387} = 3.898$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

PRE-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	100	185	85	7225
2.	125	160	35	1225
3.	105	200	95	9025
4.	165	190	25	625
5.	150	170	20	400
6.	140	150	10	100
7.	175	180	5	25
8.	140	160	20	400
9.	120	130	10	100
10.	125	180	55	3025
11.	150	185	35	1225
12.	140	165	25	625
13.	180	160	- 20	400
14.	220	235	15	225
15.	105	130	25	625
16.	155	160	5	25
17.	120	160	40	1600
18.	160	175	15	225
19.	135	160	25	625
20.	180	200	20	400
	2890	3435	+545	28125

Mean Score of Initial Test	144.50
Mean Score of Retest Six Weeks After The Conclusion of The Season	171.75
Sum of Differences	545
Sum of Differences Squared	28125

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

N = 20

D = 545

D^2 = 28125

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{28125 - \frac{(545)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}}$$

$$\frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 5.91033

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{545}{20}$ = 27.25

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{27.25}{5.910} = 4.610$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

MID-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	Mid-Season Test	Six Weeks Test	Sum of Difference	Difference Squared
1.	140	185	45	2025
2.	125	160	35	1225
3.	160	200	40	1600
4.	195	190	- 5	25
5.	140	170	30	900
6.	140	150	10	100
7.	175	180	5	25
8.	150	160	10	100
9.	145	130	- 15	225
10.	160	180	20	400
11.	140	185	45	2025
12.	135	165	30	900
13.	165	160	- 5	25
14.	195	235	40	1600
15.	115	130	15	225
16.	160	160	0	0
17.	185	160	- 25	625
18.	150	175	25	625
19.	140	160	20	400
20.	175	200	25	625
	3090	3435	+345	13675

Mean Score of Mid-Season Test	154.50
Mean Score of Test Six Weeks After The Conclusion of the Season	171.75
Sum of Differences	345
Sum of Differences Squared	13675

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

N = 20

D = +345

D^2 = 13675

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{13675 - \frac{(345)^2}{20}}}{20 - 1}$$

$$\sqrt{N}$$

$$\sqrt{20}$$

$S_{\bar{D}}$ = 4.508

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{345}{20}$ = 17.25

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{17.25}{4.508} = 3.826$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

CONCLUSION OF THE SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN ARM STRENGTH

	End of Season Test	Six Weeks Retest	Sum of Difference	Difference Squared
1.	160	185	25	625
2.	155	160	5	25
3.	180	200	20	400
4.	215	190	- 25	625
5.	160	170	10	100
6.	160	150	- 10	100
7.	165	180	15	225
8.	150	160	10	100
9.	150	130	- 20	400
10.	145	180	35	1225
11.	160	185	25	625
12.	145	165	20	400
13.	155	160	5	25
14.	230	235	5	25
15.	130	130	0	0
16.	180	160	- 20	400
17.	165	160	- 5	25
18.	150	175	25	625
19.	165	160	- 5	25
20.	190	200	10	100
	3310	3435	+125	6075

Mean Score of End of Season Test	165.50
Mean Score of Retest Six Weeks After The Conclusion of the Season	171.75
Sum of Differences	125
Sum of Differences Squared	6075

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Arm Strength GROUP Experimental

N = 20

D = +125

D^2 = 6075

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N - 1}}}{\sqrt{N}} \qquad \frac{\sqrt{\frac{6075 - \frac{(125)^2}{20}}{20 - 1}}}{\sqrt{20}}$$

$S_{\bar{D}}$ = 3.732

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{125}{20}$ = 6.25

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{6.25}{3.732} = 1.674$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

INITIAL TEST AND RETEST OF THE CONTROL GROUP IN THE HARVARD STEP TEST

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	83	82	- 1	1
2.	94	74	-20	400
3.	82	79	- 3	9
4.	91	91	0	0
5.	74	79	5	25
6.	88	77	-11	121
7.	72	75	3	9
8.	87	85	- 2	4
9.	104	110	6	36
10.	75	77	2	4
	850	829	-21	609

Mean Score of Initial Test	85.00
Mean Score of Retest	82.90
Sum of Difference	-21
Sum of Difference Squared	609

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Control

N = 10

D = -21

D^2 = 609

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_{\bar{D}}}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1}$$

$$\frac{\sqrt{609 - \frac{(-21)^2}{10}}}{10 - 1}$$

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{\sqrt{N}}$$

$$\frac{\sqrt{609 - \frac{(-21)^2}{10}}}{\sqrt{10}}$$

$S_{\bar{D}}$ = 2.505

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-21}{10}$ = -2.10

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-2.10}{2.505} = -.838$

df = N - 1 = 9

"t" at .01 level = 3.250

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AFTER ONE MONTH OF PRE-SEASON CONDITIONING OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	83	109	26	676
2.	77	99	22	484
3.	88	95	7	49
4.	87	121	34	1156
5.	100	104	4	16
6.	65	152	87	7569
7.	78	109	31	961
8.	88	86	- 2	4
9.	102	94	- 8	64
10.	95	82	- 13	169
11.	87	87	0	0
12.	82	85	3	9
13.	89	92	3	9
14.	79	115	36	1332
15.	80	94	14	196
16.	87	111	24	576
17.	81	109	28	784
18.	79	101	22	484
19.	130	106	- 24	576
20.	93	101	8	64
	1750	2052	+302	15178

Mean Score of Pre-Season Test	87.50
Mean Score of Retest After One Month	102.60
Sum of Differences	302
Sum of Differences Squared	15178

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

$N = 20$

$D = +302$

$D^2 = 15178$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} =$

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{15178 - \frac{(302)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}} = 23.041$

$\bar{D}$ (Mean Difference) $= \frac{D}{N} = \frac{302}{20} = 15.10$

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{15.10}{23.041} = .655$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST AT MID-SEASON

OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	83	135	52	2704
2.	77	117	40	1600
3.	88	134	46	2116
4.	87	136	49	2891
5.	100	115	15	225
6.	65	138	73	5329
7.	78	95	17	289
8.	88	105	17	289
9.	102	87	- 15	225
10.	95	90	- 5	25
11.	87	95	8	64
12.	82	98	16	256
13.	89	87	- 2	4
14.	79	100	21	441
15.	80	115	35	1225
16.	87	90	3	9
17.	81	113	32	1024
18.	79	97	18	324
19.	130	97	- 33	1089
20.	93	127	34	1156
	1750	2171	+421	21285

Mean Score of Pre-Season Test	87.50
Mean Score of Retest at Mid-Season	108.55
Sum of Differences	+421
Sum of Differences Squared	21285

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

N = 20

D = +421

D^2 = 21285

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N-1} \qquad \frac{\sqrt{21285 - \frac{(421)^2}{20}}}{20-1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 5.71

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{421}{20}$ = 21.05

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{21.05}{5.71} = 3.68$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Is Significant at .01 level

PRE-SEASON TEST AND RETEST AT THE CONCLUSION OF THE SEASON

OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	83	99	16	256
2.	77	102	25	625
3.	88	105	17	289
4.	87	86	- 1	1
5.	100	107	7	49
6.	65	87	22	484
7.	78	91	13	169
8.	88	93	5	25
9.	102	87	-15	225
10.	95	96	1	1
11.	87	82	- 5	25
12.	82	95	13	169
13.	89	110	21	441
14.	79	87	8	64
15.	80	89	9	81
16.	87	84	- 3	9
17.	81	87	6	36
18.	79	68	-11	121
19.	130	80	-50	2500
20.	93	109	16	256
	1750	1844	+94	5826

Mean Score of Pre-Season Test	87.50
Mean Score of Retest at the Conclusion of The Season	92.20
Sum of Differences	+94
Sum of Differences Squared	5826

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

$N = 20$

$D = 94$

$D^2 = 5826$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_{\bar{D}}}{\sqrt{N}} =$

$$\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N-1}} \qquad \sqrt{\frac{5826 - \frac{(94)^2}{20}}{20-1}}$$

$$\sqrt{N} \qquad \sqrt{20}$$

$S_{\bar{D}} = 3.764$

$\bar{D}$ (Mean Difference) $= \frac{D}{N} = \frac{94}{20} = 4.70$

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{4.70}{3.764} = 1.248$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

PRE-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	Initial Test	Retest	Sum of Difference	Difference Squared
1.	83	98	15	225
2.	77	90	13	169
3.	88	98	10	100
4.	87	78	- 9	81
5.	100	106	6	36
6.	65	82	17	289
7.	78	76	- 2	4
8.	88	93	5	25
9.	102	82	-20	400
10.	95	82	-13	169
11.	87	83	- 4	16
12.	82	75	- 7	49
13.	89	100	11	121
14.	79	75	- 4	16
15.	80	79	- 1	1
16.	87	87	0	0
17.	81	97	16	256
18.	79	91	12	144
19.	130	78	-52	2704
20.	93	86	- 7	49
	1750	1736	-14	4854

Mean Score of Initial Test	87.50
Mean Score of Retest Six Weeks After The Conclusion of The Season	86.80
Sum of Differences	-14
Sum of Differences Squared	4854

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

$N = 20$

$D = -14$

$D^2 = 4854$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \dfrac{S_{\bar{D}}}{\sqrt{N}} =$

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{4854 - \frac{(-14)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}} = 3.570$

$\bar{D}$ (Mean Difference) $= \dfrac{D}{N} = \dfrac{-14}{20} = -.70$

$t = \dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{-.70}{3.570} = -.196$

$df = N - 1 = 20 - 1 = 19$

"t" at .01 level = 2.861

Not Significant at .01 level

MID-SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	Mid-Season Test	Six Weeks Test	Sum of Difference	Difference Squared
1.	135	98	- 37	1369
2.	117	90	- 27	729
3.	134	98	- 36	1296
4.	136	78	- 58	3364
5.	115	106	- 9	81
6.	138	82	- 56	3136
7.	95	76	- 19	361
8.	105	93	- 12	144
9.	87	82	- 5	25
10.	90	82	- 8	64
11.	95	83	- 12	144
12.	98	75	- 23	529
13.	87	100	13	169
14.	100	75	- 25	625
15.	115	79	- 36	1296
16.	90	87	- 3	9
17.	113	97	- 16	256
18.	97	91	- 6	36
19.	97	78	- 19	361
20.	127	86	- 41	1681
	2171	1736	-435	15675

Mean Score of Mid-Season Test	108.55
Mean Score of Test Six Weeks After The Conclusion of The Season	86.80
Sum of Differences	-435
Sum of Differences Squared	15675

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

N = 20

D = -435

D^2 = 15675

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \qquad \frac{\sqrt{15675 - \frac{(-435)^2}{20}}}{20 - 1}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{20}}$$

$S_{\bar{D}}$ = 4.043

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-435}{20}$ = -21.75

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-21.75}{4.043} = -5.379$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

CONCLUSION OF THE SEASON TEST AND RETEST SIX WEEKS AFTER THE CONCLUSION OF THE SEASON OF THE EXPERIMENTAL GROUP IN THE HARVARD STEP TEST

	End of Season Test	Six Weeks Retest	Sum of Difference	Difference Squared
1.	99	98	- 1	1
2.	102	90	- 12	144
3.	105	98	- 7	49
4.	86	78	- 8	64
5.	107	106	- 1	1
6.	87	82	- 5	25
7.	91	76	- 15	225
8.	93	93	0	0
9.	87	82	- 5	25
10.	96	82	- 14	196
11.	82	83	1	1
12.	95	75	- 20	400
13.	110	100	- 10	100
14.	87	75	- 12	144
15.	89	79	- 10	100
16.	84	87	3	9
17.	87	97	10	100
18.	68	91	23	529
19.	80	78	- 2	4
20.	109	86	- 23	529
	1844	1736	-108	2646

Mean Score of End of Season Test	92.20
Mean Score of Retest Six Weeks After The Conclusion of The Season	86.80
Sum of Differences	-108
Sum of Differences Squared	2646

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Harvard Step Test GROUP Experimental

N = 20

D = -108

D^2 = 2646

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) = $\frac{S_D}{\sqrt{N}}$ =

$$\frac{\sqrt{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}}{N - 1} \Bigg/ \sqrt{N} \qquad \frac{\sqrt{2646 - \frac{(-108)^2}{20}}}{20 - 1} \Bigg/ \sqrt{20}$$

$S_{\bar{D}}$ = 2.329

$\bar{D}$ (Mean Difference) = $\frac{D}{N}$ = $\frac{-108}{20}$ = -5.40

$t = \frac{\bar{D}}{S_{\bar{D}}} = \frac{-5.40}{2.329} = -2.318$

df = N - 1 = 20 - 1 = 19

"t" at .01 level = 2.861

Not Significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED GROUPS FROM SMALL SAMPLES

TEST: Leg Strength

Experimental Group $\bar{D}$ = 225.75 Control Group $\bar{D}$ = 49.5

Experimental Group $S_{\bar{D}}$ = 65.956 Control Group $S_{\bar{D}}$ = 83.344

$S_{D_{M_D}}$ (the estimate of the sampling error for the distribution of differences between the mean differences.)

$$\sqrt{S_{\bar{D}_1}^2 + S_{\bar{D}_2}^2} \qquad \sqrt{(65.956)^2 + (83.344)^2}$$

$S_{D_{M_D}}$ + 106.284

$$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = (225.75) - (49.5) = 176.25$$

$$t = \frac{\bar{D}}{S_{D_{M_D}}} = \frac{175.25}{106.284} = 1.658$$

$df = (N_1 - 1) + (N_2 - 1) = 19 + 9 = 28$

"t" at .01 level = 2.763

Not Significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED GROUPS FROM SMALL SAMPLES

TEST: Back Strength

Experimental Group $\bar{D}$ = 4.50 Control Group $\bar{D}$ = -11.50

Experimental Group $S_{\bar{D}}$ = 14.729 Control Group $S_{\bar{D}}$ = 17.048

$S_{D_{M_D}}$ (the estimate of the sampling error for the distribution of differences between the mean differences.)

$$\sqrt{S_{\bar{D}_1}^2 + S_{\bar{D}_2}^2} \qquad \sqrt{(14.729)^2 + (17.048)^2}$$

$S_{D_{M_D}}$ = 22.529

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = (4.50) - (-11.5) = 16.00$

$$t = \frac{D_{\bar{D}}}{S_{D_{M_D}}} = \frac{16.00}{22.529} = .710$$

$df = (N_1 - 1) + (N_2 - 1) = 19 + 9 = 28$

"t" at .01 level = 2.763

Not Significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM UNCORRELATED GROUPS FROM SMALL SAMPLES

TEST: Arm Strength

Experimental Group $\bar{D}$ = 27.25 Control Group $\bar{D}$ = 7.00

Experimental Group $S_{\bar{D}}$ = 5.910 Control Group $S_{\bar{D}}$ = 6.333

$S_{D_{M_D}}$ (the estimate of the sampling error for the distribution of differences between the mean differences.)

$$\sqrt{S_{\bar{D}_1}^2 + S_{\bar{D}_2}^2} \qquad \sqrt{(27.25)^2 + (6.333)^2}$$

$S_{D_{M_D}}$ = 27.976

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = (27.25) - (7.00) = 20.25$

$$t = \frac{D_{\bar{D}}}{S_{D_{M_D}}} = \frac{20.25}{27.976} = .723$$

$df = (N_1 - 1) + (N_2 - 1) = 19 + 9 = 28$

"t" at .01 level = 2.763

Not Significant at .01 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS

DERIVED FROM UNCORRELATED GROUPS FROM SMALL SAMPLES

TEST: Harvard Step Test

Experimental Group $\bar{D}$ = -.70 Control Group $\bar{D}$ = -2.10

Experimental Group $S_{\bar{D}}$ = 3.570 Control Group $S_{\bar{D}}$ = 2.505

$S_{D_{M_D}}$ (the estimate of the sampling error for the distribution of differences between the mean differences.)

$$\sqrt{S_{\bar{D}_1}^2 + S_{\bar{D}_2}^2} \qquad \sqrt{(3.570)^2 + (2.505)^2}$$

$S_{D_{M_D}}$ = 4.361

$D_{\bar{D}} = \bar{D}_1 - \bar{D}_2 = (-.70) - (-2.10) = +1.40$

$$t = \frac{D_{\bar{D}}}{S_{D_{M_D}}} = \frac{1.40}{4.361} = .321$$

$df = (N_1 - 1) + (N_2 - 1) = 19 + 9 = 28$

"t" at .01 level = 2.763

Not Significant at .01 level

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